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THE COLONISATION OF WOODLAND GAPS BY FERNS AND HORSETAILS

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Key words: woodland gaps, Voorsterbos, boulder clay, ferns, spore bank, *Equisetum*

ABSTRACT

In the Voorsterbos, a planted woodland on a former sea-floor (the Netherlands), artificial gaps within stands of *Fagus sylvatica* on boulder clay were monitored for five or six years after cutting. Ten fern species and three species of horsetail established in these gaps, with *Dryopteris cristata, Thelypteris palustris, Matteuccia struthiopteris* and *Equisetum telmateia* not previously known from the Voorsterbos. *Athyrium filix-femina* was most successful and formed dense stands in some gaps. Two species (*Gymnocarpium dryopteris*, *Dryopteris cristata*) established but have since disappeared. *Thelypteris palustris* has built up a sustainable population. It seems plausible that the germination of ferns and horsetails took place during the first season following cutting of the gaps and was derived from a spore bank with an optimal microclimate with constant high moisture and humidity in the shaded part of the gaps. Competition from recruiting trees and shrubs was suppressed in some of the gaps for a period of five year through herbivory by Roe deer.

INTRODUCTION

Woodlands are the climax vegetation over much of the Earth and do not need any human intervention to be sustained. As humans need timber and fibre, they manage woodlands and harvest boles. Numerous silvicultural options are available to forest managers. They include a wide range of harvesting systems, regeneration methods and rotation lengths. Various studies have been published on the effects of harvest practices on understory and overstory conditions in managed temperate forest (e.g. Halpern & Spies 1995, Thysell & Carey 2000, Bergstedt & Milberg 2001), but with the exception of one study on *Pteridium aquilinum* (den Ouden 2000), none of them focussed on ferns.

In 1997 the management objective in one of the planted forest in the province of Flevoland (Voorsterbos) changed from timber production to ecological forestry. Homogeneous thinning with a short return interval was banned and replaced by heterogeneous thinning, artificial gap formation and longer periods of no management, in order to increase the variation within the stands and to convert single cohort stands into stands with a mosaic of phases (Koop 1989, Koop & Siebel 1993, van den Burgh *et al.* 1995, Hunter 1999). The first series of gaps in the Voorsterbos offered an opportunity for studying the effect of these gaps on the herb layer. We expected gaps would be vegetated by recruiting trees while ferns would play a subordinate role as they had been scarce in the beech stands prior to the gap formation. Natural gaps in beech

stands on sandy soil in the Speulderbos (The Veluwe, the Netherlands) showed hardly any role for ferns (two species with little cover) while rejuvenation of trees was suppressed by browsing of deer (personal observations). In the Neuenburger Urwald, an ancient Hornbeam woodland on loamy soil (*Stellario – Carpinetum*), Koop (1989) recorded few fern species colonising the natural gaps.

STUDY SITE

The Noordoostpolder was reclaimed in 1941/1942 and the Voorsterbos (Figure 1) planted in the period 1944 -1955 (Bremer 2001). The area is below mean sea level: the altitude varies from -2.5 to -1m. The Voorsterbos has been planted on sand and boulder clay. Here, *Quercus robur* dominates (48% of the area), while other tree species are less important: *Pinus* spp. (12%), *Fagus sylvatica* (8%) and *Fraxinus excelsior* (7%) (Bremer 2001). Drainage trenches were dug at a density of up to 1 km per ha in the Voorsterbos (boulder clay); their depth ranges from 0.4 m to more than 1.2m. A large area on the boulder clay has a water table at a depth of less than 0.5m in the winter. Currently the trees extract much water, making drainage by trenches less important than in the years after these woodlands were planted. In winter these trenches have a shallow water level, while in summer they are dry, only being filled after heavy rainfall. In the Voorsterbos a management strategy started in 1997, aiming to produce a shifting mosaic by making artificial gaps in various stands (Koop & Siebel 1993). In the period 2000 - 2006, 54 gaps were created by cutting down trees. The diameter of these gaps was 1.5 - 2 times tree height, and their size varied from 0.08 to 0.15ha per gap, with the exception of one gap of 0.25ha (Bremer 2007a). Nearly all the felled trees were transported with heavy equipment, causing soil disturbance over more than 50% of the surface of these gaps. All the gaps were intersected with 0.4 – 1m deep drainage trenches with a density of 1km per ha.

METHODS

This study focuses on 12 gaps in *Fagus sylvatica* stands on boulder clay in which trees were felled at the start of the years 2000, 2001 or 2004; monitoring took place in the

Figure 1. The location of the study area (Voorsterbos) in the Netherlands.

period 2000 – 2008. Each gap was monitored for a period of six years, except for three plots with a five year period. In these gaps the vegetation and recruitment of tree species were mapped, and ferns and horsetails recorded. For those ferns and horsetails that are less common in the Netherlands (listed in Table 1) individuals were mapped on 1:1000 maps, and the length of the longest frond per plant measured and the presence of spore producing fronds noted. Special attention was paid to trenches, as this habitat can be rich in fern species (Bremer 2007b). In the second year following tree felling, a 50m zone surrounding the gaps was surveyed for ferns and horsetails. These `plots` were used as controls. Shade by the trees surrounding the gaps was mapped on or near 21 June (with largest area of gap floor receiving direct light) and 21 September (the end of the astronomical summer, approximately the end of the growing season) during more or less cloudless weather. The shade line of 21 June is defined as the 100% shade line (the part of the gap south of this line is always in shade), while the shade line of 21 September is defined as the 0% shade (the part of the gap north of this line has no shade in the period between 21 June and 21 September). The position of each individual fern and horsetail (n = 25) was recorded with reference to these two lines and the number of days with shade for each was determined (Figure 2). For the group of common fern species only *Athyrium filix-femina* was analysed because it is the species most prone to desiccation. This species was analysed using a matrix of 1 x 1m plots in one of the gaps when this gap was five years old and ferns in their subadult or adult phase. Only sporophytes were included in this study, as gametophytes are difficult to monitor. The gametophyte phase was frequent in the first year after tree felling and subsequent sporophytes could be identified when two or three years old. Data were collected in August. Data on cover of the fern layer, herb layer (< 1m) and young shrub layer (> 1m) were estimated per gap in late summer.

Statistical analysis

A chi-square test was used to analyse habitat preference. A Kruskall–Wallis test was used to analyse a gradient in density of *Athyrium filix-femina* in one of the gaps.

RESULTS

Within three years the gaps were dominated by the herb or initial tree layer (< 1m in height). Fern cover reached a maximum of 21% in the fifth year (Figure 3) and varied from 1– 70% per gap. *Fraxinus excelsior* recruited at a density of more than one sapling per m^2 in 50% of the monitored gaps. In these gaps, after five years, patches of trees were able to build up a young woodland phase despite heavy browsing by Roe deer (*Capreolus capreolus*). In three other gaps shrubs and young trees present before felling were able to cover these gaps within five years. Ten fern species became established in the gaps, of which five were present in adjacent woodland zones, and three species of horsetail (Table 1). The average number of fern species per gap was at its maximum in the early years and decreased slightly after three years (Figure 4). Three fern species (*Thelypteris palustris, Dryopteris cristata, Matteuccia struthiopteris)* and one species of horsetail (*Equisetum telmateia*), had not previously been recorded in the woodland. A single plant of *Asplenium scolopendrium* was found adjacent to one of the gaps; it was not recorded within the gap habitat.

Within the gaps, ferns established on trench banks and on the woodland floor. *Athyrium filix-femina*, the most successful fern coloniser, had its highest density in the trenches ($\chi^2 = 6.5$, $p < 0.05$). The group of less common fern species (Table 1) showed no preference for trench or woodland floor habitat in terms of the population size ($\chi^2 =$

Table 1. Fern species found within 12 gaps of *Fagus sylvatica* stands (5 – 6 years after tree-felling) compared with uncut woodland surrounding these gaps, based on annual monitoring).
n g = number of gaps with species listed, **np g** = total number of estimated or counted plants/colonies in 12 gaps after six seasons, **tr** = number of gaps with species listed growing in drainage trenches, **wfl** = number of gaps with species listed growing on the woodland floor, **f** = fertility of plants after establishing in the gaps; f = with fertile fronds within four years, n.f = not fertile within four years, **sh %** = average time in shade during the period 21 June - 21 September based on plants/colonies and presented as percentage (e.g. 100% means plants are shaded during the whole season within the 21 June shade line), na = not analysed, **a** = number of 50m zones surrounding gaps with species listed, **np a** = total number of plants in 50m zones surrounding the gaps (data of all these gaps summed) after two seasons, **VB** = species found elsewhere in the Voorsterbos since 2000.

Woodland species	**Woodland gaps**								**50 m zone**			**VB**
	n g	%	np g	tr	%	wfl	%	f	sh %	a	%	np a	
Ferns													
Common species													
Athyrium filix-femina	12	100	> 1000	12	100	12	100	f	na	8	66.7	50 - 100	+
Dryopteris dilatata	11	91.7	200-400	11	91.7	11	91.7	f	na	8	66.7	50 - 100	+
Dryopteris filix-mas	8	66.7	200-400	8	66.7	8	66.7	f	na	8	66.7	50 - 100	+
Dryopteris carthusiana	6	50.0	50-100	6	50.0	5	41.5	f	na	3	25.0	25 - 50	+
Less common species													
Thelypteris palustris	7	58.3	13	3	25.0	5	41.5	n.f	84.6	0	0	0	-
Dryopteris affinis	3	16.6	3	1	8.3	2	16.7	n.f	100	1	8.3	1	+
Matteuccia struthiopteris	2	16.7	2	1	8.3	1	8.3	n.f	70.0	0	0	0	-
Dryopteris cristata	2	16.7	2	2	16.7	0	0	n.f	75.0	0	0	0	-
Gymnocarpium dryopteris	1	8.3	1	1	8.3	0	0	n.f	50.0	0	0	0	+
Polystichum aculeatum	1	8.3	1	0	0	1	8.3	n.f	100	0	0	0	+
Asplenium scolopendrium	0	0	0	0	0	0	0	-	-	1	8.3	1	+
Horsetails													
Common species													
Equisetum arvense	4	33.3	?	0	0	4	100	f	na	0	0	0	+
Equisetum fluviatile	2	16.7	3	0	0	3	100	f	100	0	0	0	+
Less common species													
Equisetum telmateia	1	8.3	2	0	0	2	100	f	100	0	0	0	-

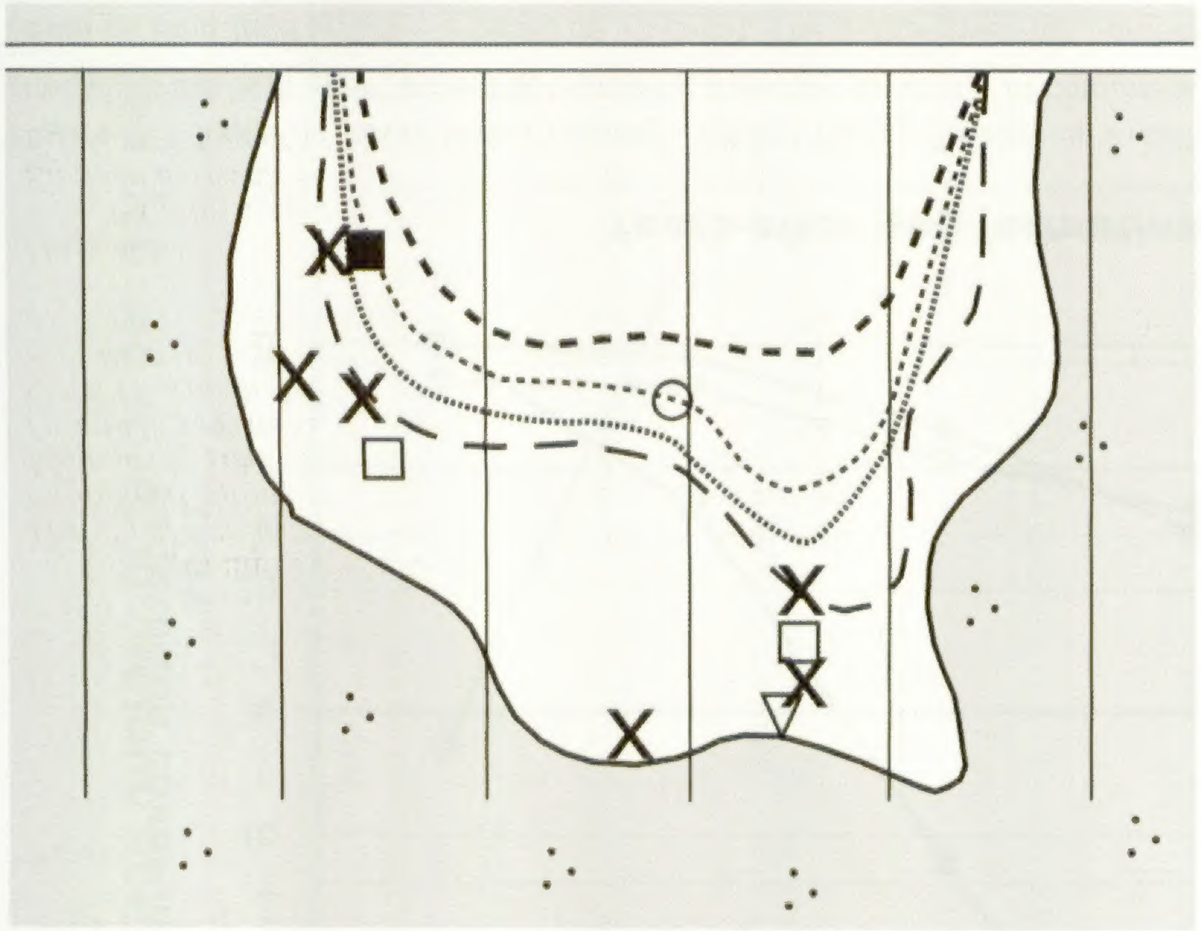

Figure 2. Woodland gap within *Fagus sylvatica* stand showing the shade lines and the distribution of rare ferns and horsetails.

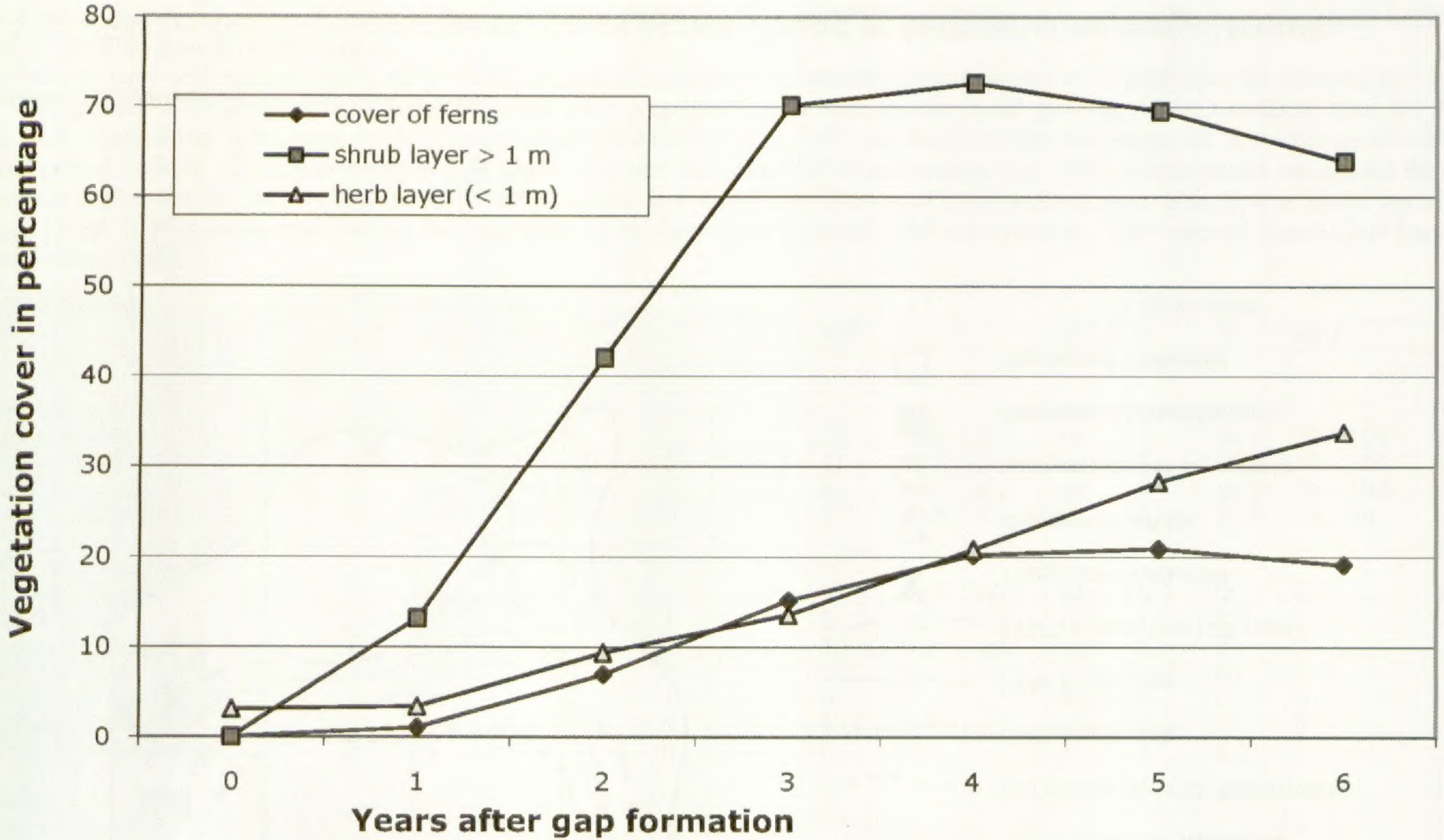

Figure 3. Change in cover layers (average values) during 7 years in woodland gaps in beech stands on boulder clay. The layer of < 1 m comprises the herb layer including recruiting trees, the layer > 1 m comprises the initial tree layer and shrub layer. Data for the sixth year are based on nine gaps (years 1-5 based on 12 gaps). The x-axis gives the number of growing seasons after gap formation.

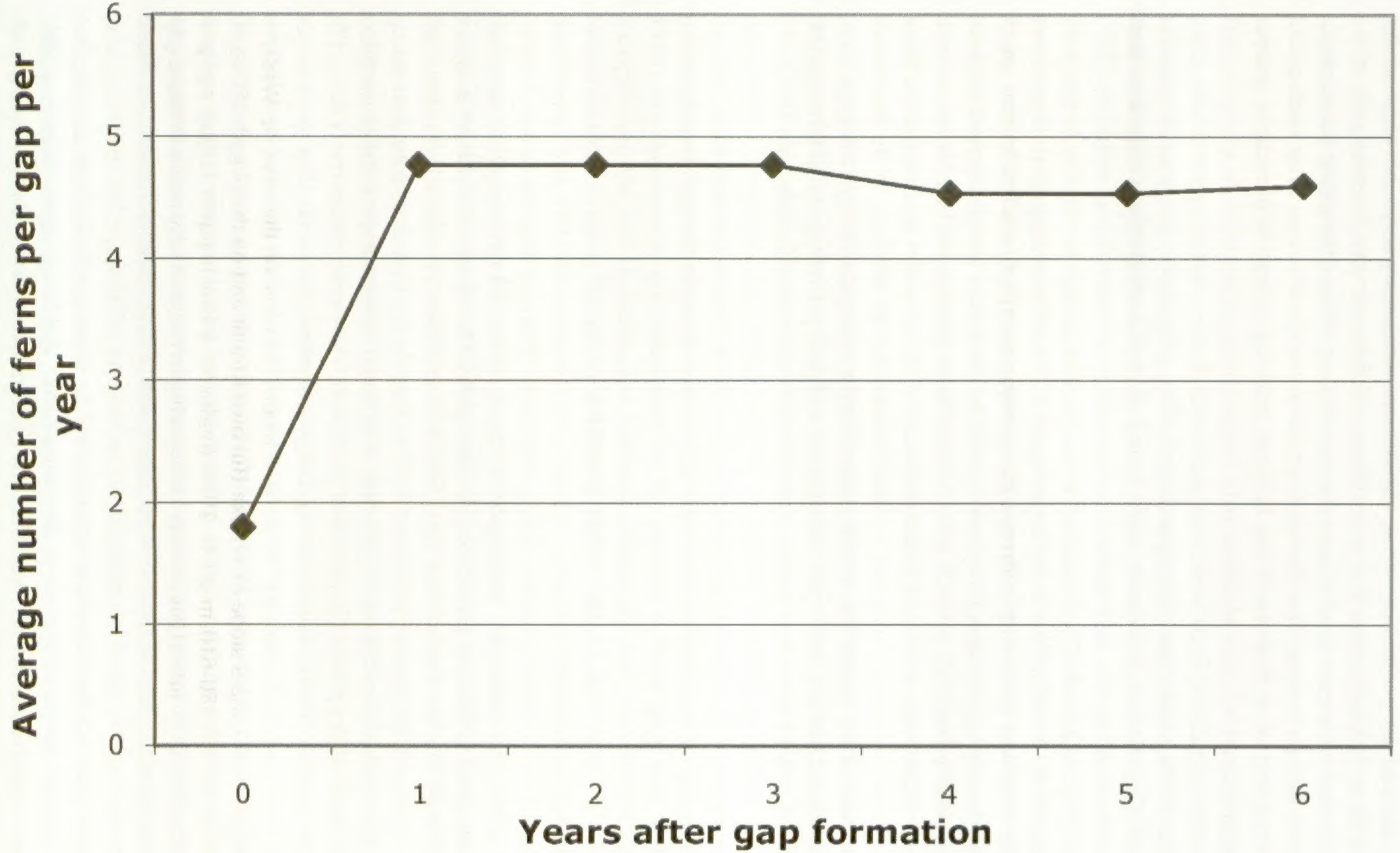

Figure 4. The average number of fern species found in the woodland gaps each year from the year before gap formation (year = 0) to six years after gap formation. Data for the sixth year are based on nine gaps (instead of 12).

0.5 n.s), but when densities were corrected for the area of both habitats there was a preference for the drainage trench habitat ($\chi^2 = 12.7$ $p < 0.001$). Plants of *Thelypteris palustris* showed no preference, while *Equisetum telmateia* was found only on the woodland floor. Fertility within four years after establishment was observed only in the group of the most common species (present in more than 49% of the gaps). Some plants of *Athyrium filix-femina* reached the adult phase in the third season after cutting and became co-dominant in five out of the 12 gaps, growing alongside horsetails, grasses and bryophytes.

The establishment of ferns was most successful in the southern parts of the gaps, within the 100% shade line: *Thelypteris palustris*, *Dryopteris cristata, Dryopteris affinis* and *Polystichum aculeatum* were found almost exclusively within this line. *Gymnocarpium dryopteris* and *Matteuccia struthiopteris* were found within the 75% shade line (Figure 2) and *Athyrium filix-femina* reached its highest density in this zone ($\chi^2 = 8.3$ $p < 0.01$ $n = 12$). Within the largest gap (0.25 ha) the average herb layer cover in the fifth year was 92%, with *Athyrium filix-femina* contributing 17%. In this gap, a gradient in density of *Athyrium filix-femina* could be correlated with the period of shade in the summer period ($\chi^2 = 10.8$ $p < 0.01$). Three species of *Equisetum* became established: *Equisetum arvense* was co-dominant with *Athyrium filix-femina* in three gaps, *Equisetum telmateia* colonised neutral boulder clay in one gap, while *Equisetum fluviatile* established within the 100% shade line in two gaps. Forty-two gaps were created in other stand and soil types. Sandy soils with low pH were poor in fern species. *Dryopteris dilatata* was present prior to tree felling and increased afterwards. In a stand of *Carpinus betulus* on boulder clay, gaps were created by bark ringing trees. Although this led to a gradual increase of light intensity, no ferns or horsetails established in these gaps, but young trees, already present in high density prior to the girdling, formed a dense stand.

DISCUSSION

Artificial gaps on boulder clay were studied in the Voorsterbos. Recruiting trees were expected to form a dense juvenile stand, contributing to the horizontal and vertical structure of the woodland. We had expected that ferns would not expand as they had been scarce prior to the gap formation, yet they proved to be successful both in cover and number of species. On boulder clay, *Fraxinus excelsior* recruits successfully, but the >1m saplings were intensely browsed by Roe Deer in the first five years, preventing a dense growth and facilitating vegetation with local dominance of *Athyrium filix-femina* at the southern parts of gaps. Other ferns were also present from the outset with, e.g., *Athyrium filix-femina* outcompeting *Gymnocarpium dryopteris*. On the boulder clay, ten ferns and three species of horsetail established; this included species not previously recorded in the area. From records of young sporophytes it appears that all these species established from spores in the first year following tree felling and soil disturbance. Spores of these species may have been derived from dry and wet spore rain to colonise the disturbed areas. However, there was a high density (establishment of >50 plants per m^2) of *Athyrium filix-femina* in five out of 12 gaps. As *Athyrium filix-femina* grew only at a low density prior to tree felling there may have been an extensive accumulation of spores preserved in the spore bank. Viable spores of *Athyrium filix-femina* were reported to be the most frequent type of fern spore in the soil spore bank in a boreal old-growth spruce forest, yet there were no plants in the herb layer (Rydgren & Hestmark 1996). In contrast in the Kuinderbos fern colonisation by numerous fern

species (with no extensive spore bank) always started with one fern individual at a particular site, followed in subsequent years sometimes by mass colonisation in the spore shadow of adult plants (Bremer 2007).

In the group of less common fern and horsetail species, the almost simultaneous colonisation within two years suggests that the spore bank may play a dominant role rather than spore rain; the spore bank here has had c. 60 years to accumulate. There appears to be no relationship between the burst of colonisation in the new gaps and the fern diversity of surrounding populations. This contrasts with the long term study (50 years) of fern colonisation in the Kuinderbos (also on a former sea floor), where Bremer (2007b) showed that colonisation of 25 fern species was correlated with the population size within 50 km from the forest.

Gymnocarpium dryopteris, *Matteuccia struthiopteris*, *Dryopteris cristata* and *Thelypteris palustris* had not previously been recorded from boulder clay in this kind of habitat within the Netherlands. All three species were able to colonise the bare soils, and thrive until eliminated by competition. A similar observation was made for a group of seed plants in the gaps, with establishment of pioneer species (e.g. *Puccinellia distans*, *Juncus gerardii*). These plants established on the boulder clay between the period of reclamation of the sea floor (1942) and afforestation (c. 1948) and must have survived the period 1948 – c. 2000 through a seed bank.

Gaps have a characteristic microclimate (Moore & Vankat 1986, Stoutjesdijk & Barkman 1992). Gaps with a diameter of less than 0.7 times the tree height do not get any direct sunlight, while in gaps with a diameter equal to the tree height, c. 80% of the gap area is shaded when the foliage is fully developed. Gaps with a diameter 1 - 2 times the tree height deviate most from the adjacent woodland, having a microclimate that is more Atlantic in summer and more continental in winter (Stoutjesdijk & Barkman 1992). As rainwater is not intercepted by the canopy in these gaps and without tree transpiration, the soil in these gaps becomes constantly wet, with on average a low saturation deficit during the growing season, while in winter there is more radiation. In the Voorsterbos, the diameter of most gaps is 1-2 times the tree height which is an optimal habitat for many terrestrial woodland ferns and horsetails. The dominance of *Athyrium filix-femina* is related to soil conditions (boulder clay with reduced percolation, moisture and neutral substrate). Godefroid *et al.* (2006) show an effect of light intensity but also a combined effect of the air temperature and air humidity on the occurrence of this species in clear cuts. The results of this study show that the less common species were confined mostly within the 100% shade line; this indicates that they prefer a constantly wet soil and high air humidity. Comparing gaps formed through tree-felling with those developed through bark-ringing demonstrates that cutting and concomitant soil disturbance is important for the germination of fern spores. *Equisetum fluviatile*, *E. telmateia* and to some extent *Matteuccia struthiopteris* are indicators of seepage (e.g. Grootjans 1985), indicating a flux of pH neutral,groundwater. That these species were found growing on impermeable boulder clay shows that seepage is not the dominant factor, but that a continuously moist, pH neutral habitat is needed, which can also be achieved by rainwater stagnating on pH neutral boulder clay. Gaps on sandy soils do not facilitate the growth of ferns, as the water percolates to the water table. When constant high humidity can be assured, one might expect species such as *Blechnum spicant*, *Osmunda regalis* and *Oreopteris limbosperma* to establish. *Matteuccia struthiopteris* is a common garden plant in the Netherlands, and occurrences of *M. struthiopteris* outwith gardens are nearly always related to garden rubbish

deposited at the edge of woodlands by man. The species established for the first time naturally in one of the planted woodlands of E.-Flevoland (province of Flevoland) in 1988 and still grows there. In the Voorsterbos it was recorded for the first time on boulder clay; a habitat not known from neighbouring countries (Bremer 2005).

In the woodland experiment, felling trees in *Fagus sylvatica* stands on boulder clay in order to make gaps facilitated the establishment and expansion of fern and horsetail populations with large differences in microclimate between gaps and the adjacent woodland. It seems likely that the crucial factors are soil composition (weakly acid - pH neutral boulder clay), moisture, and the light regime. Creating woodland gaps allows ferns to gain from their anemochoric dispersal capacity and the cumulative effect of spore dispersal (i.e. spore bank) and from the ability to develop prior to the phase in which seed plants might become dominant. Ferns, horsetails, bryophytes and liverworts are the first to establish before seed plants become dominant. Cutting woodland gaps on soils prone to desiccation would not be beneficial to the fern flora.

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BOOK REVIEW

FLORE DES MASCAREIGNES, LA REUNION, MAURICE (MAURITIUS), RODRIGUES. PTERIDOPHYTES, 1.PSILOTACEES A 26. MARSILEACEES. Published by Institut de Recherché pour le Developpement, Mauritius Sugar Industry Research Institute and Royal Botanic Gardens (Kew), Paris 2008. *Pteridophytes* by F. Badre. Pp. 452, 69 full page black and white diagnostic plates, 4 pp. col. Plates. 240 x 170 mm. Available from RBG Kew, UK price unspecified but European price is 40 euro. ISBN: 978-2-7099-1647-9.

Floras of far off tropical islands are always interesting but given that the BPS held a full excursion to La Reunion only two years ago this flora is one of the most welcome new publications in recent years. How unfortunate it could not have been published three years earlier!

Floras of these islands seem to be few and far between. Apart from J. G. Baker, *Flora of Mauritius and Seychelles: Description of flowering plants and ferns of those islands*, 1877, and Jacob de Cordemoy, *Flore de l`isle de La Reunion. Fascicule 1: Cryptogames vasculaires*, 1891, no complete fern catalogues seem to have been published. Although about 25% of the fern flora is endemic to the three islands many of the remaining taxa occur in Madagascar where floras by Tardieu-Blot and others give good coverage. The current volume would have been improved by a full history of fern research on the islands and a full fern bibliography. For a good review of all botanical research over the three islands see *Botanical History of the Mascarene Islands* by Wendy Strahm in *Curtis`s Botanical Magazine*, Vol.13, Part 4, November 1996, pp. 217-228.

The format here is concise with a very brief introduction on the classification of ferns, a key to families, then under each family a key to genera with species keys under each genus. In the body of the book the genera follow a standard systematic order with the lycophytes included at the front. There is a glossary at the end and finally a very comprehensive 38 page index. The text is in French throughout.

Each species entry gives full synonymy with authors, first publication, full description, plate number and page (if illustrated) and full distribution on the three islands. The authorship of each family varies. F. Badre is the major author but here and there specialist authors have written chapters. For example, the treatment of the *Cyatheaceae* by T. Janssen is very comprehensive, much of it based on his recent research, as is the treatment of *Lomariopsidaceae* by D. Lorence and G. Rouhan. Other major contributors include the late Prof. Holttum, the late M.-L. Tardieu-Blot (proof of the long gestation period of this volume) and J. P. Roux.

Happily I can find no discrepancies between the full species list given here and that prepared by Edmond Grangaud for the BPS excursion. I can only conclude that this volume is an accurate, concise and very welcome addition to the world`s fern floras.

This volume is part of a multi-volume set covering the complete flora of these islands; so far 25 parts have been published since the first part appeared in 1976. Currently still in production are volumes on Cyperaceae, Orchidaceae and Gramineae.

Martin Rickard

CYATHEA SLEDGEI (CYATHEACEAE): A NEW SPECIES OF TREE-FERN FROM SRI LANKA

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Key words: Tree-fern, new species, *Cyathea sledgei*, hybridisation, Sri Lanka.

ABSTRACT

Cyathea sledgei Ranil, Pushpakumara & Fras.-Jenk. is a new tree-fern species from Sri Lanka, morphologically intermediate between *C. sinuata* Hook. & Grev. and *C. hookeri* Thwaites. It is easily recognised by its simple but deeply lobed leaves; each lobe has 8-10 pairs of forked veins and 6-9 pairs of sori. It was first recorded as a putative hybrid and the origin of this species is postulated to have been directly through hybridisation between the above two species. It behaves as a species, readily forming populations and apparently being fertile. *C. sledgei* occurs among populations of the two other species, *C. hookeri* being similarly restricted in occurrence. All three species are endemic to Sri Lanka, though Large & Braggins (2004) misreported *C. sinuata* from South India.

INTRODUCTION

Interspecific and, according to some authors, inter-generic hybridisation is not uncommon in tree-ferns and has been reported by a number of authors (Conant, 1975; Tryon, 1976; Conant & Cooper-Driver, 1980; Holttum, 1984; Caluff, 2002; Caluff & Serrano, 2002; Janssen & Rakotondrainibe, 2007). Tree-fern hybrids have been reported mainly in the Cyatheaceae, but also in Dicksoniaceae (Large & Braggins, 2004, where a wider sense of the term "tree-fern" is employed, which we do not follow here). Evidence for hybridisation in the Cyatheaceae was first presented by Holttum and Sen (1961) from Malaya and from Sumatra and Borneo by Conant and Cooper-Driver (1980). Tryon (1976) published a list of ten putative hybrids from the West Indies, Mexico and Central America. Holttum (1981) and Conant *et al.* (1996) have reported hybrids from Brazil, Venezuela and Colombia. Caluff (2002) and Caluff and Serrano (2002) have provided evidence for the occurrence of four natural hybrids from Cuba. Large and Braggins (2004) tentatively reported hybrids from Australia, Tasmania, New Zealand and the Philippines and a single case has been reported from mainland Africa by Edwards (2005). A recent work by Janssen and Rakotondrainibe (2007) reported three putative hybrids from Madagascar.

However Sri Lanka is the only country in South Asia from which a putative tree-fern hybrid has been reported (Sledge, 1982). The taxon concerned was first found in

January 1951 by the late Drs W.A. Sledge and F. Ballard as a sterile plant or plants, labelled by Sledge as being collected in the Kanneliya Forest Reserve near Udugama, and labelled by Ballard as from near Panangala in Kanneliya Forest Reserve, both probably referring to the same locality and collection. From the distinctively intermediate frond-morphology, Sledge postulated that it was not an immature *Cyathea hookeri*, but represented a putative hybrid between *C. sinuata* and *C. hookeri*. Rather surprisingly it was omitted by Philcox (2007) from the *Revised Handbook of the Flora of Ceylon*, perhaps due to their being sterile collections and uncertainty as to its taxonomic status. Fifty-three years after its original collection, more than 30 individuals of the same taxon were rediscovered in Kanneliya forest reserve (Ranil *et al*., 2004). We were subsequently able to find four mature plants with ripe spores amid populations of this taxon at both Kanneliya Forest and a new locality at Sinharaja Forest.

The morphology of this taxon is constant and readily recognisable and though intermediate between the other two species mentioned there is at present no actual evidence, other than its morphological intermediacy, that it is a hybrid. This, combined with its very probable fertility (see below) and apparent formation of populations, suggests that it should be considered to be a species in its own right, even if its most likely origin would seem to have been directly from F1 hybrids between the two species. According to previous studies of *Cyathea* hybrids (see below) such plants may be expected to be fertile immediately upon formation.

It is therefore described here as follows and should be added to the list of non-Malaysian species in Asia (Holttum 1965):

Cyathea sledgei Ranil, Pushpakumara & Fras.-Jenk., ***spec. nov***. *Filix morphologia intermedia inter C. hookeri et C. sinuatam. Folia simplicia angusta profunde lobata vel pinnatifida. Sporae bene evolutae non abortivae*. (Plate 1 C, F, I; Plate 2 C, D, E, F).

Etymology: This species is named after the late Dr. W. Arthur Sledge (1904 - 1991), of the Botany Dept., University of Leeds, UK, to honour his immense contribution to knowledge of the Sri Lankan Pteridophyte flora.

Type: Sri Lanka, Sabaragamuwa Province, Ratnapura District: Sinharaja forest, 380 m alt. *R.H.G. Ranil 314*, 28 July 2008 (3 sheets), (holotype: PDA (314A); isotypes: PDA (314B, 314C).

Trunk erect, unbranched, 90-135 cm in height, 1.2-1.7cm in diameter, entirely covered by persistent dead petiole bases, leaf scars not visible, usually with few adventitious shoots. *Crown* 112-168 cm in width and 18-28 cm height, with 18-26 leaves crowded at the apex of the trunk. *Petiole* (stipe) dark brown, glossy, 4.5-4.7 cm long, 0.3-0.5 cm in diameter at its base, with blunt, 0.05-0.1 cm long squaminate spines. *Petiole-scales* 0.4-0.6 cm long, 0.1 cm wide at their base, dark brown, linear to narrowly triangular, with an apical spine, margin sometimes bearing several conspicuous dark setae, scales densely covering the young leaves. *Lamina* simple, pinnatifid about halfway to the rachis, 60-90 cm long, 3.7-5.1 cm wide, linear, light green adaxially, olive green abaxially, subcoriaceous to coriaceous. *Lobes* short, obtuse with a crenate apex, veins free, once forked, 8-10 pairs in each lobe. *Lamina-apex* gradually reduced to a serrate margin. *Lamina-base* gradually reduced, the lowest lobes deeply cut almost to the rachis. *Rachis* grooved and dark brown adaxially, light brown abaxially, glabrous and

glossy. *Sori* round, about 0.1 cm in diameter, borne at the forks of the veins, 6-9 pairs in each lobe in two rows on either side of the mid-vein, indusiate. *Indusia* globose, light brown, very thin, membranous, only a reduced disc persisting around the base of the receptacle at maturity. *Spores* well-formed, trilete, regular and not showing much variation in size or shape.

Distribution: Endemic to Sri Lanka. This species is known so far only from the Sinharaja forest in Ratnapura district (Sabaragamuwa Province) and Kanneliya forest in Galle district (Southern Province), occuring in both places along with its presumed ancestral species, *C. sinuata* and *C. hookeri*.

Habitat: Stream-side or road-side banks in lowland rain forests, 320 - 450 m alt.

Specimens examined: Sri Lanka. Sabaragamuwa Province, Ratnapura district, Sinharaja forest. *R.H.G. Ranil 314*, 28 July 2008 (6 sheets) (PDA); *idem. R.H.G. Ranil 315*, 29 July 2008 (5 sheets) (PDA); *idem. R.H.G. Ranil 319*, 29 July 2008 (PDA); *idem. R.H.G. Ranil 346*, 18 Sep 2008 (PDA); *idem. R.H.G. Ranil 347*, 18 Sep 2008 (2 sheets) (PDA). Southern Province, Galle district, Kanneliya forest reserve, near Udugama. *R.H.G. Ranil 117*, *118*, *119*, *120*, 05 Dec 2003 (PDA); *idem. R.H.G. Ranil 005R*, 22 March 2007 (PDA); *W.A. Sledge 908*, 21 Jan. 1951 (K); Panangala. *F. Ballard 1548*, 21 Jan. 1951 (K).

Note: Both presumed ancestral species are endemic to Sri Lanka. *C. sinuata* was listed by Large & Braggins (2004) as occurring in South India as well, but in error as it is not known from there. *C. sinuata* (Plate 1 A, D, G; Plate 2 A) and *C. hookeri* (Plate 1 B, E, H; Plate 2 B) are limited to a few isolated pockets in the two main lowland rain forests, Kanneliya and Sinharaja Forests. *C. sinuata* is the only *Cyathea* species known worldwide with simple leaves (Kramer, 1990) and is fairly common in its places of occurrence. The intermediate morphology (Table 1) of *C. sledgei* between a species with long, narrow, simple, strap-like fronds and another with pinnate fronds makes it very distinctive and easy to recognise. In contrast to *C. sinuata*, *C. hookeri* is very limited in numbers in both localities. All three species occur in close proximity in the same microhabitats. Sledge (1982) had mentioned previously that what he had assumed to be both parents were observed in the immediate vicinity of his collection.

A couple of small sporophytes of *C. sledgei* transferred from the wild into cultivation at Peradeniya soon grew normally and were able to produce spores. Spores of this species were cultured and germinated on a medium of soil and produced prothalli with both sexes present (Plate 2E and 2F), but did not produce sporophytes in the pots, perhaps not having the correct stages or conditions to allow fertilisation in culture.

Cytological comments: Chromosome counts of *C. sinuata* and *C. hookeri*, have shown $2n$ = c. 130-140 and n = 69-70, respectively (Manton & Sledge, 1954) and similar results were obtained by Abraham, Ninan & Mathew (1962) from Sri Lankan material. *C. sledgei* has not yet been investigated cytologically and further study is intended to be carried out at Peradeniya. All species that have been cytologically investigated so far in *Cyathea* are sexual diploids with approximately n = 69 (Tryon 1970). Conant *et al.* (1996) suggested that the family Cyatheaceae is unusual because it is the only fern-family known showing such uniformity in chromosome number and is further unusual

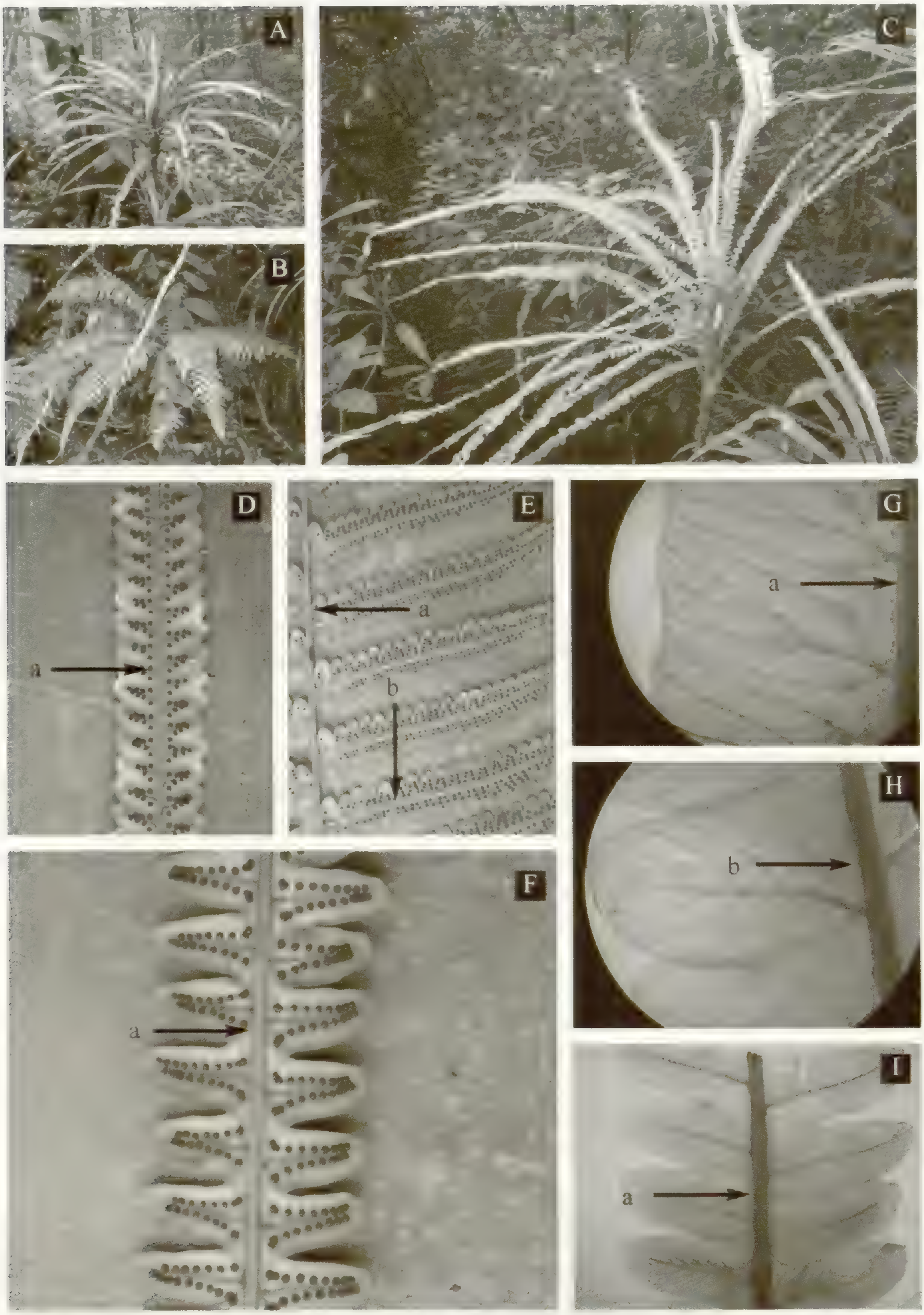

Plate 1: Habit and frond characters of *Cyathea sinuata*, *C. hookeri* and *C. sledgei* (A) Habit of *Cyathea sinuata*; (B) Habit of *Cyathea hookeri*; (C) Habit of *Cyathea sledgei*; (D) Soral arrangement of *Cyathea sinuata*; (E) Soral arrangement of *Cyathea hookeri*; (F) Soral arrangement *Cyathea sledgei*; (G) Venation of *Cyathea sinuata* (× 20); (H) Venation of *Cyathea hookeri* (× 20); (I) Venation of *Cyathea sledgei* (×1).
Note: Rachis and secondary rachis represented by **a** and **b**, respectively.

among ferns due to the occurrence of apparently fertile diploid hybrids (or hybrid-derived species) with full bivalent formation at meiosis. Thus the cytology of some hybrids recognised between the sections or genera *Alsophila* and *Nephelea* (which we prefer to treat within *Cyathea*, following Holttum, in Holttum and Tryon, 1977, due to their overall strong morphological similarity, in preference to recent molecular-based classifications) is very unusual in ferns as a full complement of bivalents are formed during meiosis between the two genomes present and viable spores are produced (Conant & Cooper-Driver, 1980), which is not due to apomixis. Conant & Cooper-Driver (1980) reported that the new world hybrids, *A. bryophila* R.M.Tryon x *C. portoricensis* Spring *ex* Kuhn, *A.* x *dryopteroides* (Maxon) R.M.Tryon (*A. amintae* Conant x *A. bryophila*) and *A. amintae* x *C. portoricensis* have 69 bivalent

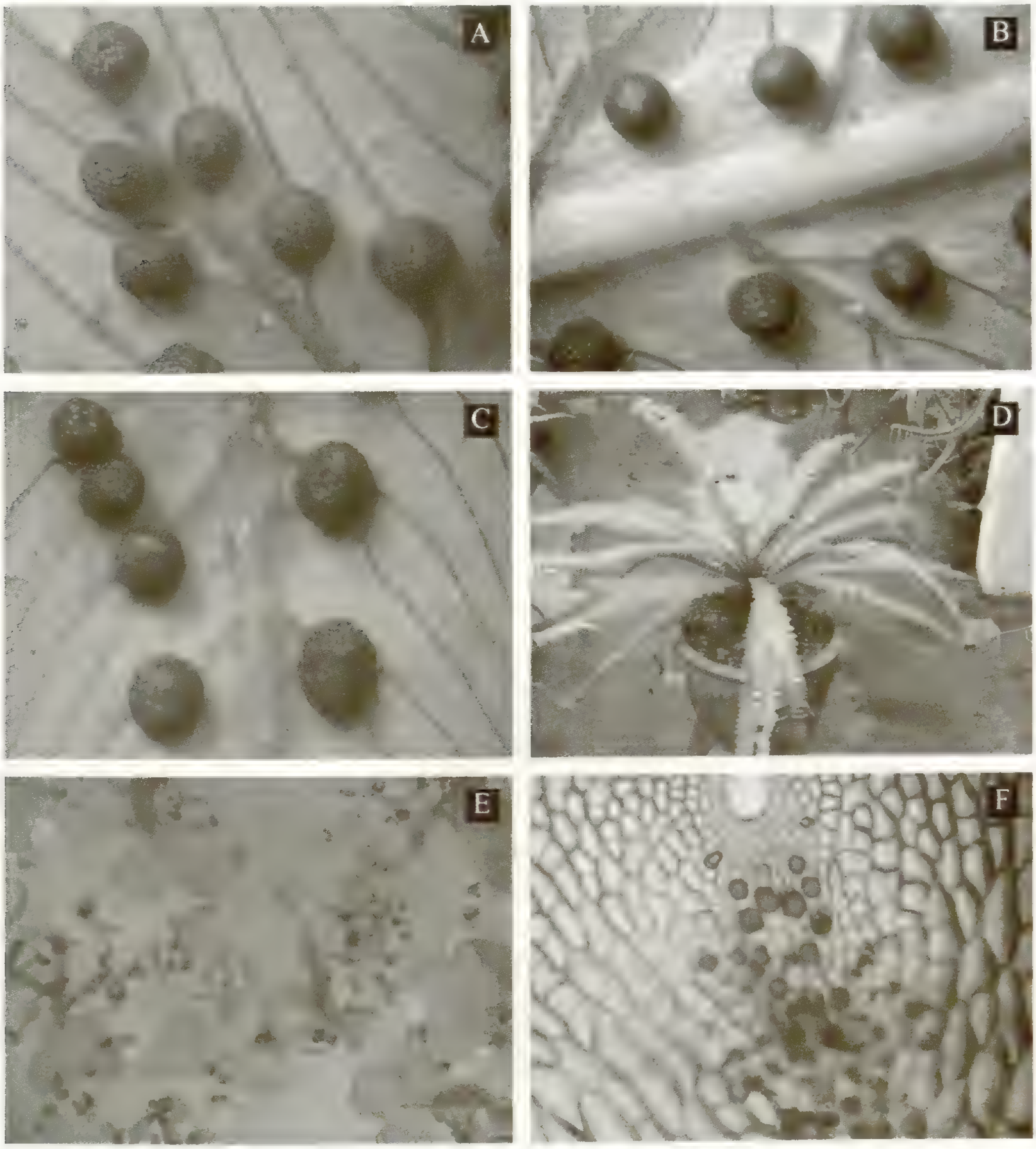

Plate 2: (A) Sori of *Cyathea sinuata* (x 40); (B) Sori of *Cyathea hookeri* (x 40); (C) Sori of *Cyathea sledgei* (x 40); (D) *Cyathea sledgei* in *ex situ* condition; (E) Developed gametophytes of *Cyathea sledgei*; (F) Gametophyte of *Cyathea sledgei* with archegonia (x 40).

Table 1: Comparison of *Cyathea sinuata*, *C. sledgei* and *C. hookeri*.

Major characters	***C. sinuata***	***C. sledgei***	***C. hookeri***
Trunk height (cm)	70-170 (-200)	90-135	100-360
Trunk diameter (cm)	1.3-1.6	1.2-1.7	2.8-3.5
Crown width (cm)	78-114	112-168	145-195
Crown height (cm)	15-25	18-28	12-28
No. of leaves	20-32	18-26	7-13
Lamina dissection	Simple	Pinnatifid	Simply pinnate
Leaf shape	Narrowly Linear	Linear	Lanceolate
Leaf base	With sinuate or entire margin	With deeply cut lobes	With separate pinnae
Petiole length (cm)	3.8-4.2	4.5-4.7	7.5-11.5
Width and length of petiole-scale (cm)	0.05-0.1 x 0.3-0.4	0.1 x 0.4-0.6	0.1 x 0.4-0.8
Density of squaminate spines on the petiole	Absent or slight	Moderate	Dense
Length of squaminate spines on the petiole (cm)	≤0.05	0.05-0.1	0.1
Length of lamina (cm)	45-56	60-90	90-120
Width of lamina (cm)	2.4-3.5	3.7-5.1	21-37.8
Veinlets	Simple	Forked	Simple
No. of pairs of sori	1-4	6-9	1-3
Soral arrangement	On 1-3 lower pairs of secondary veins	At fork of tertiary veins	On 1-3 lower pairs of quaternary veins

chromosomes at meiosis. The usual cytological methods for detecting or confirming hybridity from failure of chromosome-pairing at meiosis between the different genomes and thus production of abortive spores have not been useful in this genus. Because cytological investigation of this sort is apparently not useful to confirm hybridity in *Cyathea*, the reproductive biology and gametophyte morphology of the presumed ancestral species and *C. sledgei* are being studied further at Peradeniya and it is hoped that molecular study can also be carried out in the future to help investigate the nature and origin of *C. sledgei*. It is suggested that further consideration of the taxonomic status of what have hitherto been reported as hybrids may be required world-wide if such apparent hybrids are observed to form populations and behave as species. We would treat such taxa as species, rather than hybrids, if they demonstrate a high degree of fertility, form populations which apparently have the potential to spread and are sufficiently distinct morphologically.

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DRYOPTERIS REMOTA (A. BRAUN EX DÖLL) DRUCE (DRYOPTERIDACEAE: PTERIDOPHYTA) IN POLAND

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Keywords: *Dryopteris remota*, Poland, ferns, *Pteridophyta*, distribution;

ABSTRACT

The presence of *Dryopteris remota* (A. Braun ex Döll) Druce in Poland was unclear (Piękoś-Mirkowa 1979). Recently the presence of this species in Poland has been confirmed and this paper presents a review and description of Polish localities. Fifteen new localities of *D. remota* were found in the Beskidy Mountains (S Poland), and two contemporary and six historical sites confirmed. Ecological requirements in Poland are described. Determination of the Polish specimens of *D. remota* was based on comparison with descriptions and iconography of this species and in consultation with specialists in *Dryopteris*. A map of the distribution of *D. remota* within Poland is provided.

INTRODUCTION

The presence of *Dryopteris remota* (A. Braun ex Döll) Druce in Poland was unclear (Piękoś-Mirkowa,1979). *Dryopteris remota* had been recorded in Poland from eight sites, of which six are historical. Fraser-Jenkins (pers. comm.) reported two sites from Poland, based on a revision of Polish herbarium materials, one of which (Przemyśl) appeared on a map of the overall distribution of this species (Ekrt et al. 2007). The species has also been reported by Fiek (1881) and Shube (1903) from four sites. Two contemporary localities were reported by Kwiatkowski (2006). During 2007-2009 D. Tlałka found 15 further localities of this species in Poland (Tlałka, 2008; Tlałka & Rostański, 2008; Tlałka, 2009; Szczęśniak, Tlałka & Rostański, 2009; Wilczek, Tlałka & Rostański, 2009; Tlałka 2010), and voucher specimens were confirmed by K. Piątek. This paper presents a review and description of material from all Polish localities. A map of the distribution of *D. remota* within Poland is also presented. A detailed description of the species, nomenclature, general distribution as well as a complete literature review was published by Ekrt *et al.* (2007).

MATERIAL AND METHODS

The distribution of this species within Poland is based upon examination of specimens from the KTU herbarium (abbreviations follow Holmgren *et al.* 1990) and from the literature (Fiek, 1881; Shube, 1903; Kwiatkowski, 2006). Voucher herbarium specimens from the Carpathian localities found by Tlałka are preserved at KTU and duplicates are preserved at KRA. Phytosociological survey was made in accordance with the methodology proposed by the Zurich-Montpellier school.

ECOLOGICAL REQUIREMENTS IN POLAND

Dryopteris remota is reported from altitudes of 480 to 730 m from ravines, steep rocky

slopes and screes. It grows in forest communities, especially in Carpathian beech forest Dentario glandulosae-Fagetum. At one of the stations a phytosociological survey (relevé) was made:

Phytosociological relevé:

Dentario glandulosae-Fagetum. 16.06.2008. Porąbka, Wielka Puszcza valley, steep (50%) N slope, 550 m a.s.l., Relevé area: 100 m^2, cover of tree layer (A): 90%, cover of shrub layer (B): 1%, cover of herb layer (C): 30%. A: *Fagus sylvatica* 4. *Abies alba* +. *Fraxinus excelsior* +. *Acer pseudoplatanus* +. B: *Fagus sylvatica* +. C: ***Dryopteris remota*** +. *D. dilatata* 1. *D. carthusiana* +. *D. affinis* +. *D. filix-mas* +. *Athyrium filix-femina* 2. *Oxalis acetosella* 1. *Rubus sp.* +. *Acer pseudoplatanus* 1. *Impatiens parviflora* 1. *Abies alba* 1. *Senecio ovatus agg.* +. *Geranium robertianum* +.*Allium ursinum* +. *Dentaria glandulosa* +. *Dentaria bulbifera* +. *Carex sylvatica* +. *Aruncus dioicus* +. *Galeobdolon luteum* +. *Sorbus aucuparia* +.

RECORDS OF *DRYOPTERIS REMOTA* FROM POLAND

All currently known Polish stations of *Dryopteris remota* are presented below. The distribution map of *D. remota* in Poland is presented in Figure. 1. The map was created using cartogram method based on an artificial grid of square units 10 x 10 km (Zając A. & Zając M., 2001).

Historical records

1. Kraków-Bronowice, ATPOL square DF6911, leg. A. Rehman, rev. Fraser-Jenkins C. R. (pers. inf.);
2. Przemyśl, ATPOL square GF90, rev. Fraser-Jenkins C. R., (pers. inf.);
3. Buchberg (Bukowiec Mount), ATPOL square BE9303 (Fiek 1881);
4. Schierlischskoppe (Kostrzyna Mount), ATPOL square BE9313 (Fiek 1881);
5. Storchberg (Stożek Wielki Mount), ATPOL square BE9302 (Fiek 1881);
6. Freudenkamm (a valley in the vicinity of Sokołowsko (Görbersdorf)), ATPOL square BE9313 (Shube 1903).

Contemporary localities

7. Góry Ołowiane / Turzec, ATPOL square BE6123 (Kwiatkowski 2006);
8. Ciechanówka, ATPOL square BE7103 (Kwiatkowski 2006);
9. Beskid Mały Mountains, Wielka Puszcza valley, on the SW slope of Wielka Bukowa Mount and N slope of Beskid Mount, 540-590 a.s.l., 22 individuals in beech forest. Porąbka, Porąbka gmina, Bielsko-Biała powiat, Silesia Province, ATPOL square DF9530, **KTU**;
10. Beskid Mały Mountains, Kocierska Pass, on the N slope, Wielka Puszcza Valley, on the S slope of Wielka Bukowa Mount and on the N and NE slope of Beskid Mount, 550-610 m a.s.l., 19 individuals in beech forest and fir-spruce forest. Targanice, Andrychów gmina, Wadowice powiat, Małopolska Province; Porąbka, Porąbka gmina, Bielsko-Biała powiat, Silesia Province, ATPOL square DF9531;
11. Beskid Mały Mountains, Targaniczanka valley, on the N slope of Kiczora Mount and on the W slope of Potrójna Mount, Kiczora, on the NW slope, 530-630 m a.s.l., several hundred individuals in beech forest and fir-spruce forest, Targanice, Andrychów gmina, Wadowice powiat, Małopolska Province, ATPOL square DF9532, **KTU**;
12. Beskid Mały Mountains, Potrójna Mount between Łamana Skała and Leskowiec,

on the E slope, 630-640 m a.s.l., 2 individuals in beech forest. Targoszów, Stryszawa gmina, Sucha Beskidzka powiat, Małopolska Province, ATPOL square DF9640, **KTU**;

13. Beskid Mały Mountains, Leskowiec Mount, on the SW slope, 700-730 m a.s.l., 26 individuals in beech forest, Targoszów, Stryszawa gmina, Sucha Beskidzka powiat, Małopolskie Province, ATPOL square DF9630, **KTU**;

14. Beskid Żywiecki Mountains, Sucha Góra Mount on the SW slope, 600-620 m a.s.l., 3 individuals in fir-spruce forest, Rajcza, Rajcza gmina, Żywiec powiat, Silesia Province, ATPOL square DG2334;

15. Beskid Śląski Mountains, Jasionka valley, on the NW slope of Błatna Mount, 600 m a.s.l., 1 plant in beech forest, Brenna, Brenna gmina, Cieszyn powiat, Silesia Province, ATPOL square DG0202;

16. Beskid Mały Mountains, Łamana Skała Mount, on the SE slope above Komoniecki Cave, 720-730 m a.s.l., 15 individuals in young fir-spruce forest, Las, Ślemień gmina, Żywiec powiat, Silesia Province, ATPOL square DF9544, **KTU**;

17. Beskid Mały Mountains, Beskid Mount near Kocierska Pass on the SE slope, 650-

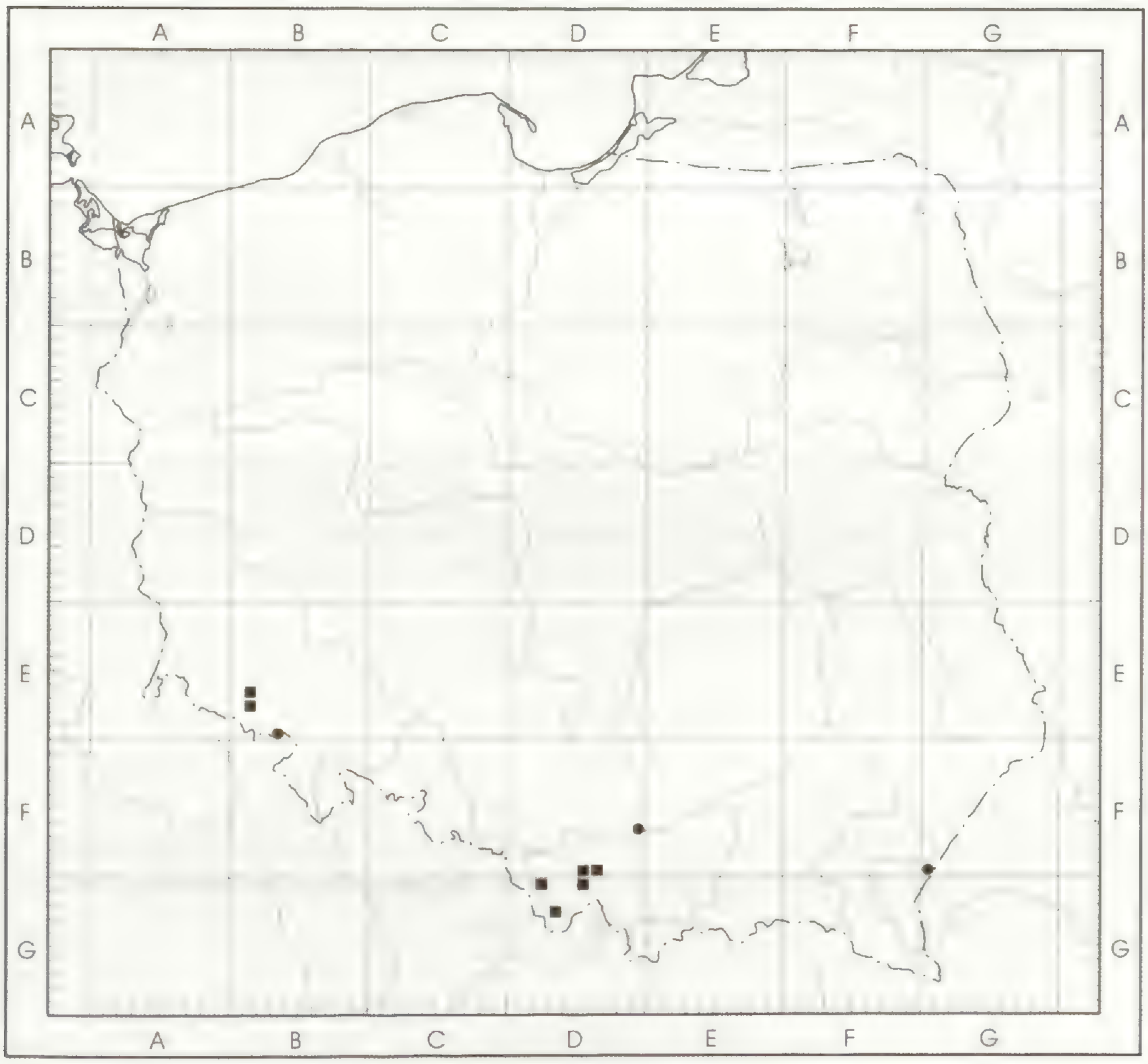

Figure 1. Map of the distribution of *Dryopteris remota* in Poland: ● – historical records, ■ – current sites.

660 m a.s.l., 4 individuals in beech forest, Kocierz Rychwałdzki, Łękawica gmina, Żywiec powiat, Silesia Province, ATPOL square DF9541;

18. Beskid Mały Mountains, Nad Płonem Mount, on the NW slope, 610-620 m a.s.l., 17 individuals in beech forest, Kocierz Rychwałdzki, Łękawica gmina, Żywiec powiat, Silesia Province, ATPOL square DG0501;

19. Beskid Mały Mountains, Mały Gibasów Wierch Mount, on the SW slope below Czarne Działy Caves, 700-710 m a.s.l., 10 individuals in beech forest, Ślemień, Ślemień gmina, Żywiec powiat, Silesia Province, ATPOL square DG0503;

20. Beskid Mały Mountains, Potrójna (Czarny Groń) Mount, on the W and SW slopes, 620-710 m. a.s.l., 10 individuals in beech forest, Targanice, Andrychów gmina, Wadowice powiat, Małopolska Province; Kocierz Rychwałdzki, Łękawica gmina, Żywiec powiat, Silesia Province, ATPOL square DF9542;

21. Beskid Mały Mountains, Kiczera, on the E slope, 530 m a.s.l., 2 individuals in beech forest, Porąbka, Porąbka gmina, Bielsko-Biała powiat, Silesia Province, ATPOL square DF9434;

22. Beskid Mały Mountains, Łamana Skała Mount, on the SE slope below Dusica waterfall, 660-680 m a.s.l., 4 individuals in young fir-spruce forest, Las, Ślemień gmina, Żywiec powiat, Silesia Province, ATPOL square DG0504;

23. Beskid Mały Mountains, Magurka Ponikiewska Mount, on the NE slope, 480-490 m a.s.l., 3 individuals in beech forest, Koziniec, Mucharz gmina, Wadowice powiat, Małopolska Province, ATPOL square DF9622.

CONCLUSION

Dryopteris remota should be included in the list of the native species of the flora of Poland. The species is probably more common, but has been overlooked. It should be included as a mountain species in the list of Zając (1996). Considering the IUCN categories and criteria (IUCN 2001), we recommend that *D. remota* should be designated as a critically endangered species (CR) in Poland.

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BOOK REVIEW

FLORA OF PENINSULA MALAYSIA. SERIES 1: FERNS AND LYCOPHYTES. VOLUME 1. Edited by B.S.Parris, R. Kiew, R.C.K. Chung, L.G. Saw & E. Soepadmo. 2010. (Malaysian Forest Records No. 48). Pp. 250, 12 black & white figs, 18 col. plates. 256 x 800mm. Forest Research Institute Malaysia, 52109 Kepong, Selangor Darul, Ehsan, Malaysia; Ministry of Natural Resources and Environment, Malaysia. ISBN:978-967-5221-24-8 (v.1). Available from Forest Research Institute Malaysia.

The *Flora of Peninsula Malaysia* is an initiative of the Malaysian Government as part of its commitment to biodiversity conservation, and it is supporting employment and training for taxonomists, fieldwork and overseas collaboration. The *Flora* is founded on thorough taxonomic review, including examination of type material, and includes ecological information. A strong focus of the project is new botanical exploration, coupled with taxonomic training, to gather information from areas where there has been little collecting in the past and review old records, to acquire up-to-date information on the status of plants, their diversity and current distributions, in order to assess conservation needs.

The last published fern flora of Peninsula Malaysia was that of Holttum in 1968 (and covered ferns but not fern allies), but he continued to publish on ferns of this region during his long retirement at Kew, contributing a number of family accounts for Flora Malesiana.

The Volume starts with a conspectus by Barbara Parris of Orders, Families and Genera, to reflect the changes in classification of ferns and fern 'allies' that have emerged from recent phylogenies based on morphological and molecular data. The editors broadly follow the treatment of Smith *et al.* (2006) in placing Equisetaceae and Psilotaceae with the ferns, rather than with lycophytes, but have modified the treatment for ferns, e.g. Pteridaceae is divided into five monophyletic families, Parkeriaceae, Adiantaceae, Cryptogrammaceae, Sinopteridaceae and Pteridaceae; Polypodiaceae is divided into three families. Loxogrammaceae, Polypodiaceae and Grammitidaceae. Justification for the changes is provided.

A further chapter by Parris deals with the history of botanical collecting in Peninsula Malaysia, followed by a chapter on species assessment and conservation by L.S.L. Chua of the Forest Research Institute Malaysia.

Keys to families, genera and species are provided. Each taxonomic account in the *Flora* includes information on nomenclature and type material, detailed description, notes on distribution together with a distribution map, conservation assessment based on the current IUCN guidelines and notes on ecology. There are useful black and white figures and coloured plates that illustrate the variation within families, and some fern habitats.

Volume 1 covers accounts for 9 families, 21 genera and 100 species, and includes Selaginellaceae, Psilotaceae, Equisetaceae, Osmundaceae, Matoniaceae, Schizaceae,

Cibotiaceae, Loxogrammaceae and Grammitidaceae.
The authors and editors are to be congratulated on a beautiful, scholarly and very valuable work.

REFERENCE

Holttum, R.E. 1968. *Revised Flora of Malaya.* Vol. 2 Ferns. 2nd ed. Government Printing Office, Singapore.

Mary Gibby

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MORTON, C.V. 1947. The American species of *Hymenophyllum*, section *Sphaeroconium*. Contr. U.S. Natl. Herb. 29(3): 139-201.
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THE FERN GAZETTE

VOLUME 18 PART 7 2010

CONTENTS

MAIN ARTICLES

The colonisation of woodland gaps by ferns and horsetails
P. Bremer 308-318

***Cyathea sledgei* (Cyatheaceae): a new species of tree-fern from Sri Lanka**
R. H. G. Ranil, D.K.N.G. Pushpakumara, T. Janssen, C.R. Fraser-Jenkins & D.S.A. Wijesundara 320-327

***Dryopteris remota* (A. Braun ex Döll) Druce (Dryopteridaceae) in Poland**
D. Tlałka & K. Piątek 328-332

BOOK REVIEWS

Flore des Mascareignes, La Reunion, Maurice (Mauritius), Rodrigues. Pteridophytes, 1. Psilotacees a 26. Marsileacees.
Martin Rickard 319

Flora of Peninsula Malaysia. Series 1: Ferns and Lycophytes. Volume 1
Mary Gibby 333-334

INSTRUCTIONS FOR AUTHORS 335

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